# Safety Report

# **AUTONOMOUS** FUTURE, **TODAY**


EasyMile brings driverless vehicle solutions for people and goods to life with leading technology, providing a real service.

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Since 2014, EasyMile has been an industry leader in the development of software specializing in autonomous vehicle technology. We focus on solutions and use cases that address a mobility need in addition to providing the highest level of safety and security. Adopting a pragmatic approach to all of our autonomous vehicle deployments, we progress step-by-step with continual improvement of our processes based on years of experience and real-world deployment globally.

Our first commercial product was the EZ10, an electric autonomous shuttle specifically designed to address the first/last mile challenge and, ultimately, provide an attractive alternative to car ownership. Today, the EZ10 driverless shuttle has been deployed in more than 30 countries around the world.

Thanks to our expertise, alongside research and development investments in robotics, computer vision and vehicle dynamics, EasyMile develops and deploys fully driverless mobility solutions. These range from selection and integration of the sensor set, software development that enables automation for various transportation platforms, to in-house fleet management solutions. EasyMile provides these solutions for various types of vehicles, either for transporting passengers or for logistics on private sites, urban, suburban or rural areas in diverse environments. We already have a global reach with offices in Toulouse (France), Denver (USA), Berlin (Germany), Adelaide (Australia), and Singapore.

Safety and risk management is at the heart of everything that EasyMile does – from software development to vehicle testing and on-road deployments, and it's reflected in our no-collision record and clear safety road map. Safety is our main priority. As part of this culture, EasyMile is one of the first autonomous driving technology companies to have obtained, and maintained, ISO9001 certification. But what does this mean? It is a process-based standard that demonstrates our ability to consistently meet customer and regulatory requirements and to demonstrate continuous improvement.

This report details our company's safety priority throughout our technology development, deployment, and validation processes. It outlines how we address each of NHTSA's 12 Safety Points and is intended to provide transparent information for NHTSA and the general public.
—

Gilbert Gagnaire
*Founder and CEO*

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Since
**2014**

30+ PhDs

**250+**

Leader
in R&D

**5**
locations

**22**
nationalités

# EZ10

## ELECTRIC AUTONOMOUS SHUTTLE

—

25 mph

**EZ**10
Targeted maximum vehicle speed

ADA compliant

Up to 12 people (6 seated, 6 standing)

16h autonomy 12h with A/C

Pre-mapped network of roads

Wide vision: sees up to 320ft at front and 130ft to sides

# TRACTEASY

## ELECTRIC AUTONOMOUS TOW TRACTOR

—

15 mph

**TRACT**EASY
Targeted maximum vehicle speed

Ground clearance of 150 mm

Detects and avoids all obstacles with a full set of sensors

KG

Pulls up to 25 tonnes

Wide vision: sees up to 320ft at front and 130ft to sides

Designed to operate in harsh weather conditions


**EasyMile is focusing this Voluntary Safety Self-Assessment on the EZ10 as these vehicles transport people on public roads. Many of the safety features are also relevant for the TractEasy.**

## 1.1 Introducing the EZ10

The EZ10 is an electric, driverless shuttle. Six seated passengers can enjoy a ride onboard the EZ10, in addition to carrying a passenger in a wheelchair. With no steering wheel or pedals, the EZ10 can navigate autonomously and is targeted to travel up to 25 miles per hour. It can operate for up to 16 hours on one battery charge. The EZ10 mobility service can provide on-route or on-demand services, travelling on a fixed route or providing door-to-door services within a specific road network.

The EZ10 drives on pre-mapped routes and is designed to perform the entire dynamic driving operation within a specified geographic area, under certain defined conditions, and without the need for a human driver. Based on the Society of Automotive Engineers (SAE) International's definition of automation, the EZ10 is targeted to be a Level 4 automated driving system.

**FULLY DRIVERLESS OPERATION**
While most Level 4 automated driving systems still require Safety Operators in the vehicles, EasyMile is proud to be one of the first companies to target a fully driverless operation (with no safety operator). EasyMile has designed the EZ10 with appropriate levels of safety and system redundancies to enable its safe operation with entirely remote supervision in specified operational design domains.

Today, there are more than 150 EZ10s operating all over the world in a variety of spaces including city centers, university campuses, corporate campuses, hospitals, and stadiums. These shuttles operate safely and effectively in a wide range of environments, including varying traffic conditions (segregated road, mixed traffic with bicycles and pedestrians, mixed traffic with low speed cars, etc.) and various weather conditions (extreme heat, snow, rain, etc.).

## 1.2 Introducing EZFleet

EasyMile developed EZFleet, its own Fleet Management system, which is able to manage a connected group (or fleet) of any type of autonomous vehicles. It is designed to be flexible and modular so that it can enable different operating scenarios and adapt to the various needs of our customers. The connection between the EZFleet and the EZ10 vehicles is secured with the latest Transport Layer Security (TLS) standard and authentication certificate - ensuring privacy and data integrity between the two communicating computer applications.

There are four key functions of EZFleet:
**CONTROL CENTER** – via the EZFleet interface, the supervisor is able to see all vehicles, their position, assigned routes and destinations, as well as several vehicle parameters, including the inside temperature, batteries state of charge, vehicle weight, and other data. EZFleet supervises the vehicle fleet and ensures everything runs smoothly.

**MISSION MANAGER** – EZFleet performs many tasks including: dynamically and optimally assign missions, send a vehicle to a charging location, and switch between fixed route and on-demand service.

**PASSENGER EXPERIENCE** – via a CCTV camera and speakers, a remote supervisor can view and communicate directly with passengers. Additionally, the passenger screen can be updated in real-time to provide geolocalized information, emergency procedures, next stops, estimated time of arrival, etc.

**DATA, REPORT, AND STATISTICS** – EZFleet provides useful data which can be used to improve overall operations. Information is gathered from the vehicle, site, and operations, and the system automatically creates monthly operating reports.


ON BOARD DISPLAY

TRAVELER APP

API MONITORING

**DATA ANALYTICS**

API BOOKING

**DISPATCHER**

API MISSION

CONTROL CENTER

**FM CORE**

**COMMUNICATION & SECURITY**

e2.10

Tract Easy

Other driverless vehicles

# 2. A company founded on safety

Our commitment to product and system safety is at the heart of all EasyMile activities. This has been true since day one and will continue to drive our innovation and growth without compromise.

**THIS FIVE PILLARS PRINCIPLE GOVERNS OUR SYSTEM SAFETY MISSION:**

**1. DESIGN**
When we design our products the main priority is to achieve a high level of safety consistent with their application, always ensuring that we meet or exceed the relevant legal, regulatory, and industry requirements. We are proactive in assessing potential risks and to putting controls in place, taking all reasonable precautions to mitigate safety risks.

**2. VALIDATION AND PROCESSES**
Robust quality is an essential part of product safety and - by following our standardized, repeatable, and documented processes - we make sure that our products and those of our suppliers meet expectations. EasyMile is ISO 9001 certified for specification, design, development, integration, validation, manufacturing, sales, supply, deployment and support of automatization systems, autonomous vehicles, fleet management systems and autonomous transport systems. This certification demonstrates our ability to consistently meet requirements and to demonstrate continuous improvement.

**3. DEPLOYMENT**
EasyMile's deployment process starts and ends with safety at its core. EasyMile has a strict route review process that involves a cross-functional group of EasyMile staff assessing potential risks and mitigation strategies. Additionally, EasyMile staff or trained partners are on-site to validate any infrastructure requirements, set-up the agreed route, and conduct established tests, to ensure the project can be deployed safely.

**4. CONTINUOUS IMPROVEMENT**
We are committed to continuously improving product safety and actively engage in setting industry standards and good practices. We measure our performance and rigorously investigate and resolve safety-related issues, systematically embedding the knowledge gained back into our practices and processes. In addition, the EasyMile mindset of all employees is to report any product safety concerns.

In addition, by working collaboratively with our partner vehicle manufacturers - either original equipment manufacturers or logistics companies - and through our daily exchanges with the largest public transport operators worldwide, we are constantly receiving valuable experience and feedback that enable us to improve our safety approach. These partnerships ensure that we always develop and maintain state-of-the-art methodologies.

**5. CULTURE**
Our management champions and prioritizes product safety so that safety-related tasks get the right attention, time, and resources. This priority cascades down and is clearly and consistently communicated throughout every area of the company, worldwide. It is made clear to every employee what they are accountable for and everyone takes ownership of product safety, collectively and personally.

Because everyone at EasyMile shares responsibility for product safety and needs to be aware of the implications of their actions in this respect, we conduct awareness presentations to ensure and enhance our employees' understanding of the EasyMile product security policy and processes.
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A-HUSET
EASY MILE
RAU 85N


NHTSA

## 3. NHTSA's twelve safety elements

The U.S. Department of Transportation publication, "Automated Driving Systems, A Vision for Safety 2.0", outlines twelve safety elements that are relevant globally and "generally considered to be the most salient design aspects to consider and address when developing, testing, and deploying Autonomous Driving Systems on public roadways."

**The following pages outline how EasyMile has incorporated each of these safety elements into our driverless shuttle design, deployment, and operations.** EasyMile also takes into account the guidance within the publications "Preparing for the Future of Transportation: Automated Vehicles 3.0", which expands the scope of 2.0 to all surface on-road transportation systems, and "Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0" which builds upon 3.0 by expanding the scope to 38 relevant United States Government (USG) components to ensure a consistent approach to autonomous vehicle technologies.

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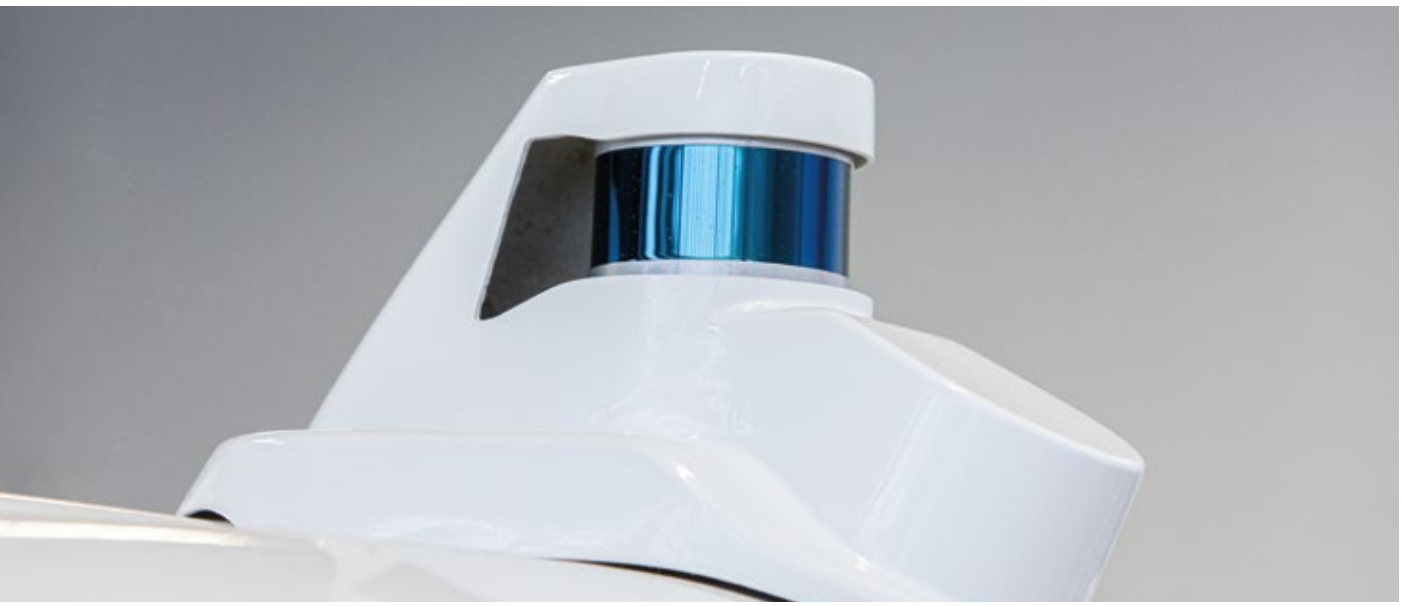
## 3.1 System safety - *Safe by Design*

The EasyMile safety system is a culmination of our vision for autonomous vehicles, strategies to test and develop Automated Driving Systems, and the fundamental platform of our software, instrumentation, and deployment philosophy.

Our EZ10 vehicles are designed around a suite of instruments that constantly and robustly monitor the vehicle's environment and orientation within that environment. These instruments include LIDAR sensors - LIDAR stands for Light Detection and Ranging - which use laser pulses to build a 3D model of the EZ10s environment. Essentially, LIDAR sensors help autonomous vehicles "see" other objects, including cars, pedestrians, and cyclists. This technology operates with extreme speed and accuracy, providing a complete 360 degree view around the vehicle with very precise measurements to all objects, obstacles, and landmarks within an established radius. The EZ10 uses a variety of different LIDAR sensors, some of which are tuned for obstacle detection and others that are better suited for landmark recognition and localization.

Working with the LIDAR sensors, the EZ10 also uses finely adjusted GPS data and measurements of vehicle accelerations and distances to determine its exact location and orientation - known as "localization". Because all the data from the EasyMile sensors works together, there is high visibility around the vehicle by at least two LIDAR sensors due to their overlapping ranges. Also, distances to objects are agreed upon by LIDAR readings and algorithms - this clever combination allows instantaneous calculations to be made relating to the vehicle position based on real-time data from the GPS, odometer, and accelerometer.




“Overall certainty” is a factor we use to describe how accurately the EZ10 is localizing from a combination of all our data streams. Making safety paramount, our software only allows EasyMile vehicles to operate if the overall certainty is within safe boundaries - so, if overall certainty decreases, the maximum speed allowed also decreases, and if overall certainty falls outside of the safe boundary then the EZ10 stops and either waits for better data (an increase in certainty) or is driven manually by the operator until the safe conditions resume.

Our EasyMile engineers have a wide variety of experience from industries such as automotive, aerospace, and defense, and they follow a development plan that uses principles and best practices from them all. We tirelessly test new developments on virtual test-beds, in controlled lab tests, and on private proving grounds. Once proven, the Autonomous Driving System is deployed on EZ10s all around the world. It doesn’t stop there though as data is continuously collected from each individual vehicle and used to begin work developing the next generation of technology. The quest for continuous improvement is recognized by EasyMile and we take advantage of every opportunity.
Our risk management approach is defined as “comprehensive and system-oriented”, and is fully integrated into the heart of our Quality Insurance System, which is ISO 9001:2015 certified.

“Comprehensive” means we consider risk management from the early stages of product design until the very last day of operations - hence covering the whole life cycle of every project and involving every stakeholder at the right level.

“System-oriented” because, since the earliest days of EasyMile, we have considered our autonomous vehicles to be components of a global transportation system, interfacing with other components and for which risk management has to be globally implemented.

For every project, the following key risk-management activities are implemented consistently in order to compile a 3-layer safety case, dealing with:

| **Product Safety** | **Deployment Safety** | **Operational Safety** |
|---|---|---|
| i.e. Vehicle Safety, aiming to ensure the overall safety of the Autonomous Vehicle in the context of a generic intended use. | aiming to identify every risk associated with the specific characteristics of a site, and to define the additional external measures to be implemented in order to mitigate every identified risk to acceptable levels. | aiming to ensure the definition and implementation of the operational procedures consistent with every safety requirement identified during the 2 previous layers. |

# Product safety


The development of an autonomous vehicle requires specific processes to be put in place to guide every aspect of the design of each element of the vehicle, indexed according to two categories:
• Vehicle-platform technical entities (chassis, suspensions, body, passenger-compartment, etc.), and;
• Electric and Electronic systems (hardware and software).

The design of the vehicle-platform technical entities is governed by the implementation of the relevant road-vehicle regulatory requirements (for more information see the following sections on “Crashworthiness” and “Federal, State, Local Laws”).

The safety of the safety-critical Electric and Electronic embedded systems is driven by the implementation of and adherence to international standards, most notably: ISO 26262:2018 “Road vehicles – functional safety”.

Implementing these standards allows EasyMile to identify every possible hazardous scenario that may occur during the intended use, caused by system failures or by external events, and t ne the safety requirements and the validation strategies in order to mitigate these risks.

In order to address system safety during development, a highly specialized team devise and follow processes utilising their experience and knowledge of safety systems and protocols in the automotive, rail and aerospace industries. They continuously interact with the system, development (hardware and software), and validation teams in order to implement these key standards.

State-of-the-art engineering tools are used in order to maintain a consistent approach for risk identification, solutions implementation, and verification of their effectiveness. Examples include preliminary and systematic hazard analyses (PHA, FHA, etc.), deductive analyses (FTA, etc.), and inductive analyses (FMEA, FMES, etc.).

As a result, our autonomous vehicles are designed with a distributed architecture - this means the different components are hosted on different platforms and communicate through a network. This design ensures that there are duplications of subsystems (redundancies) and independences between various autonomous driving systems with clearly known limits of use, i.e. the validated “Operation Design Domain”. For an explanation of this and more information see the dedicated chapters 2 and 3 below.
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# Deployment safety

**300+ deployments around the world**

Thanks to a track record of 300+ deployments around the world, representing a total of 450,000 miles driven in autonomous mode, our operational safety processes have been developed from real operating experiences with an extensive variety of challenging environmental conditions and operational situations commonly faced by our automated shuttles.

A fully-dedicated global field services team of high-skilled engineers and project managers are involved in the deployment process.

A systematic risk analysis of every section of each new site/route and its specific characteristics are performed through our well established and robust procedures that have been, and continue to be, improved with each deployment.

Considering the vehicle safety case and its related validated operational design domain, these analyses consist of:

| | | | |
|---|---|---|---|
| Comparing the known limits of the vehicle against the specific sections of the desired routes. | Identifying and assessing every related risk. | Reducing any residual risk to an acceptable level by implementing external risk reduction strategies to the site infrastructure, traffic rules, and operational organization. | Compiling the results into the deployment safety case. |

# Workflow “deployment safety to operational safety”

1

**SITE ASSESSMENT**

Before the vehicle arrives on-site, one of EasyMile’s deployment engineers identifies and documents all potential risks and mitigation strategies along the proposed route. Based on these findings, the EasyMile team develops a Site Assessment Report, which summarizes EasyMile’s requirements and recommendations for the site. The team then reviews the findings with the customer, assesses the feasibility of the proposed routes, and ensures that all of these recommendations are appropriately addressed prior to finalizing the vehicles’ route location and operating assignment.

2

**SITE SET-UP**

This occurs once the vehicle is on-site. An EasyMile engineer manually drives the EZ10 along the entirety of the routes on site with the purpose of “pre-learning” the possible routes and operating environment. Over the following days, the vehicle creates a “reference map” that represents all routes and the site environment. The vehicle then knows its exact position by comparing its perceived environment to the “reference map.”

3

**TRAINING**

EasyMile’s training team has trained over 800 external staff around the world. The operations curriculum focuses on how to operate and manually drive the EZ10 and how to handle passenger communications. This training is delivered during the setup phase, once the vehicle is onsite, and before operations begin.

4

**OPERATIONS**

Once all prior steps are complete, the EZ10 is ready to be deployed for operations.

5

**SUPPORT**

The EasyMile software development team is constantly developing improvements and upgrades for the EZ10. Additionally, the EasyMile team monitors all operations to ensure the safe and successful use of our driverless shuttles.

# Operational safety

Our EZ10s provide transport for members of the public and are managed by trained Safety Operators. These Safety Operators are responsible for the implementation and management of the safe operation of the autonomous vehicles.

Our procedures aim to ensure consistency with the requirements of the product safety case and deployment safety case. They do this by specifying operational requirements which cover operating rules, supervision tasks, preventive maintenance, incident management and more.

Finally, every operation feeds our continuous improvement process: EasyMile constantly monitors all the data which comes to us from each vehicle's embedded systems in order to identify, design and implement improvements.

2

## 3.2 Operational design domain

In order for our vehicles to operate with the highest level of safety, our concerns and focus extend far beyond the vehicle and into the wider environment in which it operates. Long before the vehicle ever arrives on location, our team has worked with the project stakeholders  to choose a route that is well within our safety standards while still providing the service requested.

While EasyMile is continually improving our safety systems to operate the vehicle in more diverse and dynamic environments, our current technology works best in environments with: well paved and maintained roads; lower speed vehicle traffic; fair weather including moderate rain, snow, or fog; areas with abundant rigid structures to orient the vehicle; and sloped terrain with less than a 15% gradient. Some complex traffic interactions, such as traffic lights, can also be navigated with the use of connected vehicle technologies.

At EasyMile we are constantly seeking to expand our operational design domain by challenging ourselves with test routes in environments that push us to find creative and robust solutions to complex and difficult environments. From the frozen winters of Minnesota to the scorching summers in Dubai, from rainy Singapore to snowy Calgary, from the bustling streets of downtown Gainesville, Florida, to the wide open spaces around our office in Denver - we have met the challenges presented and used the experiences to evolve our technologies and approach to provide reliable and safe operations in diverse environments around the world. We believe that it is the environments that challenge our technology are also where and when people need the service we can provide the most, and our goal is to provide those services at the highest standards of safety.

3

## 3.3 Object and Event Detection and Response (OEDR)

Object and Event Detection and Response (OEDR) is a core safety feature of the EZ10. To be able to detect any object or event and to react appropriately, the OEDR addresses two main objectives:
• Ensure safety for the passengers and the other road users (including pedestrians, cyclists, and any other vulnerable road users as well as other vehicles); and
• Ensure the comfort of the passengers and the whole journey experience.

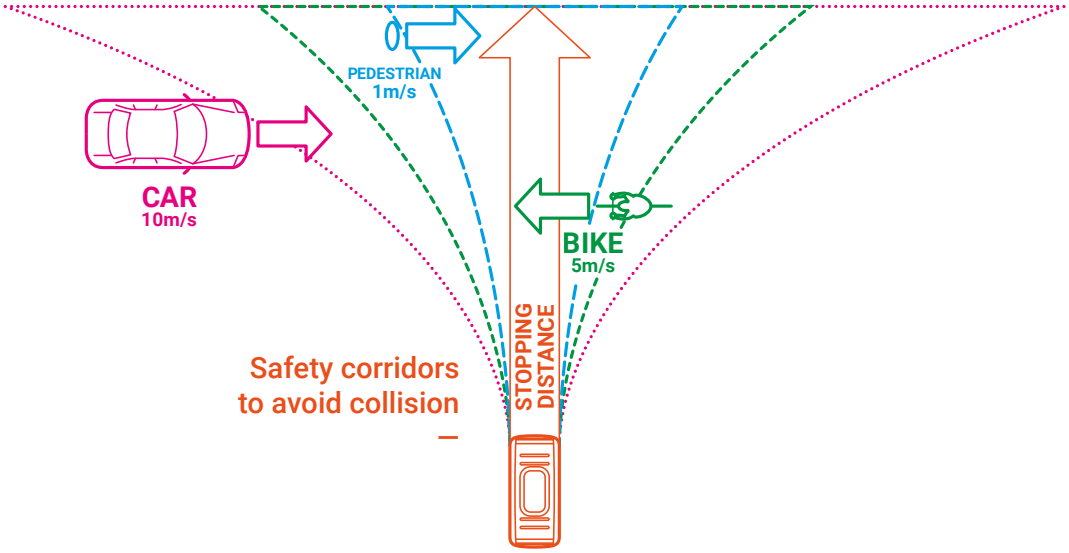
To maximize availability and safety, the OEDR is managed by redundant features, implemented in several subsystems. In engineering, a redundant feature is one that is a duplicate with the intention of increasing the reliability of a system to improve performance and safety. These redundant sensors detect obstacles on the road, as well as events (e.g. traffic light phase change, localization uncertainty, trajectory deviation, etc.), and then adapt the vehicle's behavior as needed. This architecture, composed of independent and redundant systems using an intentional mix of technologies, reduces the risk of common failures.

These systems also ensure continuous monitoring of critical components including, for example, steering and traction controllers, braking systems, sensors, emergency push buttons, main computers and engine control units, etc. A failure by either one of the two independent systems, or by one of the critical components, will trigger a fail-safe state.

The real-time steering, speed, and braking capabilities are constantly being calculated by algorithms that refer to the vehicle's surroundings and state in relation to its predicted path. If there is a risk of collision or deviation from the course, the OEDR technology calculates the appropriate trajectory and deceleration of the EZ10.

## Operational Safety

To make the system safe by design, we have specified safe behaviors with respect to objects detected and we have implemented this with the safe two-level design (independent and redundant subsystems) explained above. The safe behavior of the system is designed specifically to protect a vulnerable road user in worst-case scenarios. Given our current operational design domain, the worst-case scenario today is a pedestrian walking alongside the vehicle and suddenly crossing in front of it. This scenario can be modelled with simple equations that create a relationship between:
• The vehicle's speed and acceleration, and
• The distance to the pedestrian and its speed when it crosses the vehicle's trajectory.




In order to guarantee that a collision won't occur with a pedestrian in this worst-case scenario we have to define a "safety corridor" around the trajectory. The width of this corridor depends on the hypothesis we pose about pedestrian's speed when it crosses.

Other scenarios based upon a vehicle or pedestrian lying within the trajectory of the vehicle are managed by a specific response related to the braking distance of the vehicle. This is managed by the combination of its deceleration weight and the speed of the vehicle. For an obstacle lying in front of the vehicle, deceleration is applied so that the vehicle stops with a clearance zone before the obstacle. We also provide requirements about the maximum speed of other obstacles (i.e. other vehicles) within which we can guarantee the absence of collision.

In order to apply this trajectory and deceleration safety strategy appropriately, the EZ10 is equipped with several independent braking systems, such as regenerative, hydraulic and electrical calipers, and fail-safe brakes.

## Other events

The system is able to respond to several other types of events as well as obstacle collision avoidance. Adequate behaviors have been defined for intersection crossings (with or without traffic lights), arrival and departure at a station, pedestrian crossings, obstacle circumvention, etc.

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## 3.4 Fall back

The EZ10s fall back mode depends upon the safest response to the critical situation. The EZ10s response will depend on how critical the hazardous event is and defaults to the safest outcome for the passengers and other road users. If any critical embedded system is not functioning appropriately, the EZ10 has been designed to do one of the following:

- Switch to alternative mode (reduced speed to the next station, etc.), or
- Ensure a safe stop in minimal risk conditions (soft stop or emergency stop).

The EZ10s are always being monitored. This monitoring occurs via a Safety Operator in the vehicle or a Remote Supervisor using our fleet management system. If anything is not operating as intended, the system sends alerts and the Safety Operator/Remote Supervisor can follow established operational procedures in response.

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# 3.5 Validation methods

EasyMile has developed testing and validation approaches for all aspects of the EZ10s physical platform and the software.

## EZ10 platform validation

EasyMile's industrial partner, Ligier, has unparalleled know-how when it comes to setting up production lines for new vehicles. Ligier established a dedicated EZ10 production line that follows the automotive industry's best practices. In 2018, Ligier produced over 15,000 electric vehicles and, to date, they have manufactured over 150 EZ10s. Ligier is continuously improving production, materials, and design. Due to the complexity of the EZ10, a specific validation of each vehicle is done with comprehensive and extensive testing that is controlled by Ligier's quality department.

After physical validation of the vehicle, each EZ10 is also tested in autonomous mode at the factory, operating over approximately 30 miles on a dedicated track. Once received at EasyMile's test facility in Toulouse (France), every vehicle is tested and validated again, and at the deployment sites.
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In a Ligier factory, in Abrest, on April 18, 2017-AFP / Archives / Thierry Zoccolan


## Hardware and software validation

EasyMile is constantly advancing its driverless technology with new functionality that enables the EZ10 to operate in increasingly complex environments. It is important that each release has been tested and validated to ensure reliable and safe operations. For this reason, on both the software and hardware sides, EasyMile has developed its own verification and validation process.

EasyMile has a dedicated team of engineers whose sole purpose is to test and validate EasyMile's driverless software and hardware. The test and validation team is in charge of validating the system operationally, and every time a new version of the software is released it goes through an established validation plan. Each function of the system is tested operationally leading to various tests that depend on the complexity of the function. All the issues found during the validation process are reported and managed through a proprietary issue tracking tool.

At the end the test and validation team delivers a validation report to the system and the deployment teams, listing all the tested functions and their status. This report is then used by the deployment team to define the conditions in which the vehicles can operate safely.

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## 3.6 Human machine interface

Just like any vehicle where passengers do not have contact with the driver, the EZ10 needs a way to communicate information to individuals onboard. Safety signage clearly indicates the emergency brakes, emergency exits, fire extinguisher, and safety information. A large screen inside the vehicle displays the list of destinations and the progress between them. The screen also presents useful information in case of unexpected stops or other delays.

Passengers can get further information and summon the vehicle to a destination via a smartphone app. This app, and the information screen, can also be enhanced or supplemented to include information like connecting transit services, weather, landmarks, and other useful information. Additionally, informative videos or static graphical displays can be presented to passengers.

The vehicle can also play queued audio announcements anywhere along the route to prepare the passengers for departure, call out landmarks, or signify upcoming stops. All these announcements can be customized to fit the needs of the site.

If a passenger has a question or concern, a clearly labeled button opens a two-way communication between them and a remote fleet manager. Passengers in wheelchairs or with mobility limitations can press the clearly labeled accessibility ramp button to extend the ramp and lower the vehicle.

Outside, the vehicle indicates its intent just as other drivers do; via turn signals, hazard lights, and brake lights. Also, in lieu of a horn, the vehicle has a bell to alert other drivers or pedestrians of the vehicle's approach. By request, an LED display can be installed on the vehicle to provide even further information to individuals outside.
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## 3.7 Vehicle cybersecurity

Cybersecurity is one of Easymile's main priorities throughout the development of its software, site set-up, and operations. While most of the other safety categories outlined in this report aim to protect the system from accidental failures, cybersecurity focuses on protecting the system from intentional attacks. EasyMile is committed to ensuring its autonomous vehicles and all associated technology systems are both as safe and secure as possible.

International standards for autonomous vehicle security are not yet available. Therefore, EasyMile has adopted the best practices published by the company SAE International (a neutral forum that supports the aerospace, automotive and commercial vehicle industries) in their publication "SAE J3061". These best practices include organizational and technical aspects of vehicle cybersecurity, governance, risk management, security by design, threat detection and incident response and recovering.

Some of the key protection areas of the EasyMile's autonomous vehicles are outlined here:

- In order to prevent malicious or unauthorized access to the components, all physical ports (such as USB or Ethernet, etc.) are physically protected or disabled.
- Parts of the network are segregated by firewalls in a way that physically and logically prevents communication between components which are not supposed to talk to each other.
- All communications with any external systems are kept to a minimum in order to decrease the access and, consequently, the potential risk.
- The system's firmware validates the cryptographic signature of EasyMile software prior to allowing the vehicle to run. Therefore, any code lacking EasyMile's cryptographic signature cannot operate.
- An obstacle detection safety stack runs in an independent loop. In the unlikely event of an attacker accessing the main system, the vehicle would still remain protected from accidents because the safety chain would activate upon obstacle detection.
- The software in the cloud was conceived in such a way that, even if hacked, the safety of the vehicle is not compromised.

Finally, EasyMile performs pentests and external audits annually during which both the EZ10s and the EZFleet are evaluated to assess their overall cybersecurity. For instance, the EZ10 has been subject to threat analyses. The results are used to further enhance the security of our products.

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## 3.8 Crashworthiness

The EZ10 has been designed, and is only ever deployed, in such a way that minimizes the risk or consequences of a crash. Additionally, the technology is constantly moni- toring and communicating any operational risks or occurrences.

### Protection against rollover crash

A rollover crash is often the major contributor to serious injuries in vehicle accidents. Rollover crashes are divided into two subcategories: untripped and tripped.

A tripped rollover occurs when a collision forces the EZ10 to rollover, which is an unlikely scenario due to the shuttle weight and slow speed.

An untripped rollover would result from physics and dynamics (e.g. entering a curve at high speed) and is addressed during EasyMile's deployment process and safety functions. All of the vehicle dynamics parameters (e.g. speed, steering angle, lateral acceleration) are reviewed and programmed prior to deployment (more detail in the next paragraph). Further, once the EZ10 is operational it is continuously controlled, and if it is ever required, the technology will activate safety behavior like limiting the vehicle speed. These active safety functions assure vehicle stability and substantially contribute to the prevention of any rollover occurrence or crash.

### Protection during site risk analysis

The EasyMile deployment process includes an in-depth analysis of the risks that may occur on each site. Our collision risk evaluation undertakes an assessment of all potential road users (e.g. pedestrians, vehicles, cyclists, etc.) together with their size, speed and trajectory. EasyMile then proposes actions to mitigate each risk. For example, collision risks can be addressed by lane markings, speed limit changes, traffic lights/stop signs, etc.

### Protection from lateral collapse - EZ10 structure

The EZ10 chassis has been designed with a robust roof structure that can, for example, provide protection against severe passenger injuries if a lateral rollover were to occur. This strong global chassis structure is designed to ensure safety with two types of frames: aluminium for the vehicle structure and steel for sub-structures, including, for example, the engine's assembly.

## Additional safety factors

There are several additional vehicle safety features that mitigate the risk of any crash:
• Automatic emergency braking in case any obstacle is detected within the EZ10s trajectory;
• The system continually monitors any potential deviation from the EZ10s assigned trajectory. Any deviation will trigger automatic emergency braking.
• Seat belts are available in the EZ10. The seatbelts are anchored at two points which is adequate because passengers do not have a solid structure in front of them that could result in any head or leg impact; and
• For standing passengers, the EZ10 interior has been designed to minimize the risk of injuries due to an absence of sharp corners, screen edges, etc.
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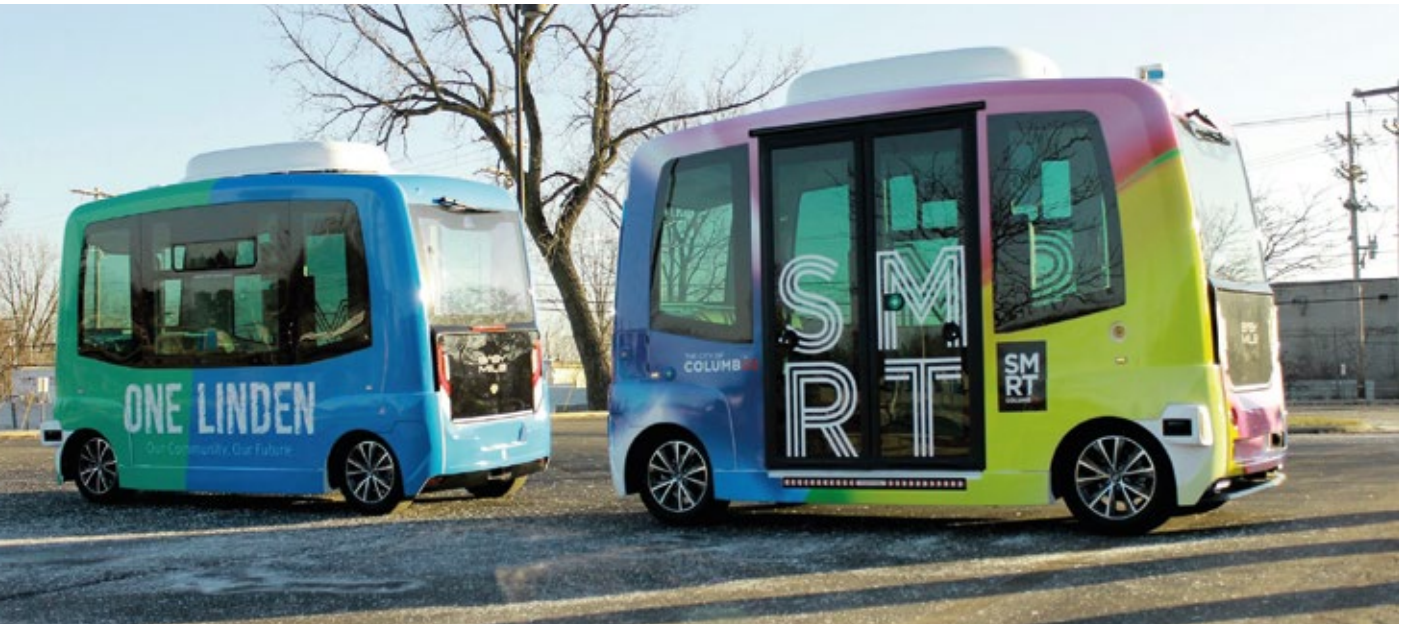
## 3.9 Post-crash behavior

When the EZ10 detects a near-crash situation, or detects that it is involved in a collision, an emergency stop occurs instantaneously, followed by the activation of the hazard lights (flashers), and the activation of the fail-safe brake in order to keep the EZ10 stationary.

An emergency alert is sent to the fleet management system, allowing the operational team to implement the required emergency procedures, as well as alert the emergency services, if required. EasyMile and its partners work with local emergency responders during our deployment process to ensure that they understand the locations of the safety switches, the emergency exits, batteries, etc.

As described in the section about the “Human Machine Interface,” the EZ10 is also equipped with an intercom and video surveillance system, allowing the supervision team to assess the situation and communicate with the passengers (assuming no safety operator is present). If a safety operator is present, he/she would respond based on traditional emergency response protocols.

The doors of the EZ10 are equipped with a fail-safe unlocking system, which can be activated from the inside or outside of the EZ10 (either by passengers or emergency personnel). There are also additional emergency exits, which have been designed to ensure the most timely passenger evacuation. Fire extinguishers and a first aid kit are also available within the EZ10.



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## 3.10 Data recording and sharing

EasyMile recognizes that data sharing is an important aspect of any driverless vehicle deployment. Project stakeholders are interested in advancing their knowledge of the driverless technology in addition to ensuring the vehicles' operational safety and informing planning processes. As such, the EasyMile technology enables data sharing with all project stakeholders.

EasyMile, via its fleet management system (EZFleet), collects and stores data on the technical condition of the vehicle every half-second. This data contains the results from the information processed and analyzed by the vehicle such as:

- Safety monitoring metrics (e.g. battery, power train, door status, emergency stop triggers),
- Vehicle position,
- Assignments sent to the vehicle by the supervision system, and
- Usage statistics.

This, and other operational information, can be shared via a few different application programming interface (API) options.

The EZ10 is also equipped with a "black box" module. This module records the raw data from the various sensors that is exchanged between the vehicle's hardware and software. If there is a critical event, all data prior to and after the event are recorded to help understand and diagnose the event in post-processing, using dedicated tools with data replay and analysis capabilities.

EasyMile has already shared data and reports with all of its project stakeholders, including the National Highway Traffic Safety Administration (NHTSA), public transit agencies, Departments of Transportation, and cities.

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## 3.11 Consumer education and training

As one of the first companies to have a commercially-available driverless vehicle, EasyMile has been educating the general public about the potential of driverless technology for years. Since our driverless shuttles were first deployed, EasyMile has introduced the technology to more than 450,000 people globally. The first driverless shuttles introduced in the United States were in March 2017 when GoMentum Station began testing them. Since then, EasyMile's shuttles have been deployed in Texas, Florida, Michigan, Colorado, and many other states.

With over 50 deployments in the United States, EasyMile has participated in countless stakeholder and community workshops. These workshops provide an opportunity for community members to learn about driverless technology, ask questions, and hear about how driverless shuttles can positively impact their daily lives. Additionally, our deployments involve educational sessions with emergency responders, including police, firefighters, and emergency medical personnel.

Throughout our deployments, many of our partners conduct surveys to assess passenger perceptions both before and after their ride experience. This provides our team with valuable feedback that is constantly being integrated into the EasyMile technology roadmap.

EasyMile has also worked with clients globally to help educate government regulators at the federal, state and local levels. In the United States, EasyMile has spent time with the National Highway Traffic Safety Administration (NHTSA), the Federal Transit Administration (FTA), the U.S. VOLPE Center and the Federal Highway Administration (FHWA). EasyMile has worked with Departments of Transport and Departments of Motor Vehicles in all of the states it has operated in and, in many cases, EasyMile has worked with cities, transit agencies, universities, and industry groups as all organizations have become involved in autonomous vehicle deployments.

Training is a key component of EasyMile's deployment processes. The EasyMile training team has developed multiple training curriculums in order for our partners to be reliable and independent in safely deploying, operating, and maintaining our EZ10s, in addition to communicating effectively with passengers. Our training team has conducted training modules for over 800 staff around the world. All training modules are well-documented and all trainees are audited regularly to ensure quality benchmarks are always met.
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## 3.12 Federal, state, and local laws

EasyMile has been working with federal, state, and local government agencies globally to ensure that the EZ10s are deployed with all of the appropriate regulatory approvals. Additionally, EasyMile has worked with government agencies to assist their development of autonomous vehicle regulations.
The following outlines how EasyMile works with Federal, State, and local government organizations in the United States.

### Federal

EasyMile is required to get an exemption from NHTSA in order to import the EZ10s since they do not comply with the existing Federal Motor Vehicle Safety Standards (FMVSS). In October 2018, NHTSA updated their process for granting these approvals and EasyMile was the first to apply and be approved for projects using this new process. The process requires EasyMile to submit detailed project and vehicle information for every new deployment. To date, EasyMile has received over 50 of these project, and vehicle specific, approvals.

### State and Local

Every State has different policies and regulations regarding public road autonomous vehicle deployments, including everything from licensing and insurance to permits. EasyMile has and will continue to work with relevant leaders at the Departments of Transportation, Departments of Motor Vehicles, and cities to ensure all state and local requirements are met. To-date, EasyMile has successfully worked with state and local government agencies for public road deployment approvals in California, Colorado, North Carolina, and many other states.

### Global

EasyMile is also working in other countries with local authorities and approval centers or agencies for the approval of all EZ10 deployments on public roads. For example, EasyMile is working with and has obtained formal approval for complex deployments from TUV (Technical Inspection Association) and DEKRA (Motor Vehicle Inspection Association) in Germany, as well as UTAC CERAM a private, independent French group providing services in all areas of land transport: Regulation and Approval, testing and technical expertise (environment, safety, durability and reliability), certification, events and driver training.

**France headquarters**
21, boulevard de la Marquette
Hall B,  Level 3
31000 Toulouse

**North America headquarters**
6144 North Panasonic Way
Denver, CO, 80249 USA
+1 (970) 670-0052

**www.easymile.com**